XXVIII. *Observations on the* Ergot *of Rye, and some other Grasses.*

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Read December 4th, 1838.

HAVING heard the observations on the nature of Ergot, communicated to the Linnean Society on the evening of November 7, by Mr. John Smith, of the Royal Botanic Garden at Kew, and having been engaged previously in the same investigation, which has been directed not only to the cause but to the structure, growth, and manner of reproduction of certain bodies connected with the formation of this singular substance, it occurred to me that the following might prove an useful sequel to the former by making the history of this production more complete, and confirming some of the views therein expressed.

The investigation of this subject has often occupied the attention of both English and foreign botanists*, with the view of determining its nature and origin, yet notwithstanding the mystery belonging to it has not been completely

* A list of some of the foreign authors who have written on the nature of Ergot, whose works have been consulted:—

Tessier: *Traité des Maladies des Grains.* Paris, 1783.

DeCandolle: in vol. 2. *Mémoires du Muséum d'Histoire Naturelle.* 1815.

Desfontaines: in Trans. Acad. Scien. Paris. 1816.

Leveillè: *Mémoire sur l'Ergot*; Ann. Soc. Linn. Paris, vol. v. 1827.

Philippar: *Traité Organographique et Physiologico-agricole sur l'Ergot, &c., dans les Céreales.* Versailles, 1837.

Phœbus: *Deutschlands Kryptogamische Giftgewächse.* Berlin, 1838. On whose authority the following are given:

Wiggers: *Inquisitio in Secale cornutum*; Comm. præm. orn. Gott. 1831—4.

Diez: *Verss. über die Wirkungen des Mutterkorns*; Gekroute Preissch. Tüb. 1832.

Dierbach: *Die neuesten Entdeckungen in dem Mat. Med.* I. 1837.

Etzrodt: *Das Mutterkorn*; Inaugural-Abh. Würzb. 1838.

removed, the observations published by some of the later authorities have gone far towards our viewing this production in a clearer light, especially those of Leveillè, Philippar, and Phœbus, from whom we learn much interesting matter, and also the history and former hypotheses respecting the Ergot, which here will be omitted, for the sake of brevity.

On examining* the spikes of the infected grasses whilst recent, there could be observed lodged between the paleæ of the flowers (bearing ergots) a quantity of a viscid fluid, which appears to exude from them; and on others could be seen an appearance as if something slimy had once been smeared over them. On submitting the fluid to the microscope, it was found to be composed of an infinite number of particles, mixed with some liquid, and whose number alone appeared to cause its viscidity, the taste and smell it afforded being of a faintly sweet character, even when examined in minute quantities.

On examining the slimy appearances, which are of a darkish colour, that occur on certain paleæ of Elymus, Rye, and other grasses, the same numberless particles could be detected, when the viscid matter was dissolved that had fastened them to such a situation, which made it evident that these marks were occasioned by some of the viscid liquid having applied to these organs, and become dry from the loss of some portion of its watery constituents.

Having ascertained these facts, it was conceived that these minute bodies in the liquid were connected with the means by which the ergot was occasioned and propagated, and were considered to be the *sporidia* of some fungus: therefore, how the liquid was generated, formed the next step in the inquiry, as being an important part of the mystery.

This viscid liquid has been observed by most of the preceding investigators. Tessier, in his *Traité des Maladies des Grains* (1783, p. 37), speaks thus: "J'ai vu ainsi que quelques physiciens, sur des epis de seigle un suc visqueux, luisant, d'un goût mielleux, qui enduisait l'intérieur, l'extérieur et les arètes même des balles ou étaient renfermés des ergots naissans; mais plusieurs balles etant

* The observations that follow have resulted from the examination of some recent specimens of Ergot on the *Elymus sabulosus*, presented to me by Mr. John Smith, and from those on Rye and several other grasses kindly lent me by J. Pereira, Esq., being the first examples that I had the opportunity of examining in a recent state; having often observed the specimens in the state in which they occur in the shops without ever being able to make out anything satisfactory respecting this anomalous formation.

privées de ce suc, quoiqu'elles contenissent de jeunes ergots, je ne puis prononcer sur la cause qui le produit, ni sur la part qu'il a à la formation de l'ergot." From this it appears to be difficult to determine from whence the liquid escapes, and also it teaches us that it is not always present.

Leveillé in his *Mémoire sur l'Ergot* (Annales Soc. Linn. Paris, 1827, vol. 5, p. 570,) gives it as his opinion, that the presence of the liquid always precedes the formation of the ergot, and from other observations states, "De plus elles nous ont appris que ce suc est un champignon dont le mode de developpement, l'organization et les effets meritent la plus grande attention": this, however, does not determine its origin; but (p. 571) it is stated, "Si ce champignon traverse les glumes sans éprouver d'accident, on le voit à l'extrémité de l'ergot, ou il forme un tubercule jaune." "Il laisse écouler un liquide visqueux:" here is stated the source of "a viscid liquid," which it is imagined is identical with the one under consideration, which is said to exude from the fungus at the apex of the ergot; but it will be attempted to be shown hereafter that this considered fungus is in reality not one, but a portion of the diseased ovary; therefore, if the fluid escapes from this, it in all probability has its origin in the diseased grain.

Philippar (*Traité &c. sur l'Ergot du Seigle*, p. 111,) inclines to the opinion of the internal origin of this viscid liquid in the following words: "En remontant à la source de ce liquide, on voit qu'il s'extravase d'un centre floral." (p. 115.) "La transudation du liquide cesse insensiblement et lorsque l'ergot a acquis tout son accroissement il n'y a plus de transudation." From these observations it appears that the liquid escapes from the ergot; but still it would be a matter of some interest to ascertain the precise point from which it flows, and to acquire other information respecting it.

Having ascertained the healthy structure of the young grain, the observations were directed to the earliest appearance of the ergot; and it was found that when influenced in its growth by the presence of a parasitic fungus (hereafter described), its healthy state was lost at a very early period, by the rapid germination of the latter, which, like others of its kindred, generated in a short time an inconceivable number of reproductive atoms.

The first appearance of the young grain changing from its healthy condition is manifested by its appearing swollen and softened, and possessing, as Leveillé and Philippar have described, a fetid disagreeable odour: in this state it breaks

very easily in a transverse or any other direction, on very little force being exerted for that purpose; it exhibits at this period, under the microscope, its surface covered with a white mealy coating, which is mixed with cotton-like filaments*, separating with the utmost facility when the ergot is placed in water and means are used for detaching it. This coating is not confined to the body of the grain exclusively, for the particles and filaments of which it is composed run over the anthers and stigmas, cementing them into one mass; this fact is mentioned by Leveillé, and figured by Philippar; the particles being found on the anther is noticed also by Mr. Smith, and they have been detected by myself on the glumes and paleæ.

This coating, when examined microscopically, is found to be composed of minute bodies (sporidia), which are seen separated from each other when they are removed from the ergot; but when viewed in their natural situation they are seen occasionally united by their extremities, forming short moniliform filaments; but for the most part they are found irregularly agglutinated to the surface, their connexion with each other being so easily disturbed if moisture be applied to them. The coating is not smoothly distributed as regards the surface it covers, but is composed of numerous flakes and also of sinuous ridges†, similar to the convolutions on the exterior of the human brain, which are arranged longitudinally upon the apex of the ergot, but diminish toward the base, and are most distinct when the specimens are about half grown.

At this stage the whole diseased grain does not measure more than one sixth or one eighth of an inch, and the stigmas have become somewhat shrivelled, whilst the few hairs on its apex, and also the two scales at its base remain unchanged. If a transverse section be made, it shows scarcely anything but sporidia arranged about a very small and soft axis, which is of a lobed, triangular, or irregular form; this axis is the grain very much altered from its normal condition, and presenting scarcely any analogy to the others which retain their healthy character.

* Besides these filaments, there are others which appear to me as if they belonged to some other parasite, which selects a damp situation for its growth, and have no share in the production of the ergot, their joints being not like those of the true coating, having seldom any granules within them, and being more nearly rectangular than elliptical, and occurring on many parts of the grass, and not always on the body of the ergot.

† See TAB. XXXII. figg. 4 and 7.

As the ergot enlarges, there does not appear to be a corresponding increase in the production of sporidia, but rather a diminution; for when it has attained a size sufficient to protrude beyond the paleæ, it has given over supporting any longer the increase of the reproductive particles which occupy its surface, and seemingly infected with something communicated by, or abstracted from, these bodies, grows with rapidity in a diseased condition, and in a short time emerges beyond the paleæ with apparently few of the sporidia on its exterior; those that existed in the young state being now either detached from external causes, or spread over a larger surface.

When a transverse section is made before the ergot protrudes beyond the paleæ, its consistence is found to have become more solid, still, however, presenting a sinuous or lobed margin; and immediately within the external border, which is composed of sporidia agglutinated to the diseased grain, there begins to appear a purplish line, which is gradually shaded off inwardly till it merges into a brownish white centre.

After the ergot has shown itself beyond the paleæ the growth is still rapidly proceeding, and it soon attains a size varying in different grasses from a fifth of an inch to one inch and a half. This part of the growth is accomplished in a very short period of time, as Philippar mentions that he observed some particular ears of rye having no visible ergots, when in eight or ten days subsequently he found the same plants had then perfect ones upon them. At this period its surface begins to be deprived of the white coating of sporidia, a few only remaining in flaky patches, which give to it the "sub-pruinose" appearance mentioned as one of the characters of the genus *Spermoedia,* and the purple coat that formerly was concealed underneath it, is now its outermost covering, and begins to lose its lobed and furrowed surface from being distended by the development of the central part: at this period, though the ergot is in a great part exposed, it has not lost all traces of the stigmas or of the scales, but they are now become shrivelled, and its apex is surmounted by an appendage* (to which Phœbus applies the term "*mützchen,*" bearing the remains of the hairy crown observable on the healthy grain, and which Leveillé considers as the fungus which produces the ergot.

The transverse section at this period presents a firm slice, which, when

* See Tab. XXXII. fig. 9.

viewed as a transparent object with a low magnifying power, exhibits a granular centre surrounded by a purplish border: the longitudinal section shows the same granular appearance along its middle part, bounded also on either side by the purple border. There is now something deceptive about these objects if immersed in water, there being then observed issuing from them myriads of minute particles resembling sporidia, which completely fill the field of view. These however are not sporidia, but particles of an oily nature, together with certain other granules the cells contain (analogous to those found in the healthy grain with the fecula), which now float out from the divided cells, and may be readily taken, as they were by Philippar, for sporidia, if the magnifying power be not sufficiently distinct and powerful.

As the ergot approaches maturity its colour becomes dark purple*, and its surface generally presents many cracks and fissures: its shape at this time is subject to much variation, being generally elongated and tapering away at each end, sometimes occurring quite straight, at others slightly or very much curved, there being besides these many other forms of length and thickness constantly observed; its section transversely is more or less triangular, and presents a furrow on one or both sides, especially in the rye, though these are not discoverable in the ergots of all grasses.

When the ergot has arrived at its perfect development, it still retains in those specimens that have not been exposed to injury the appendage at its apex, a few hairs surrounding the remains of the stigmas, and likewise the two scales at its base, which appear but very little changed, and its surface has now become almost deprived of sporidia.

It appears from the examination of the healthy grains of rye that the ergot corresponds to the seed without its pericarpial covering; for it is found that the grain of the rye has two distinct layers for its pericarp, the outer being very thin and composed of elongated cells, whose longer axis is perpendicular, and the inner of elongated cells also, but the longer axis is horizontal: within these two layers is a line of some width, which is coloured of a reddish brown tint and connected by its inner side to a layer of cells, which have somewhat

* In several instances ergots have been found not of a violet black colour, but of different lighter shades, and even of the colour of the healthy grain.

the arrangement of the stones which form the arch of a bridge. This coat appears to answer to the testa of the seed, and also to the external or purple one of the ergot, the colouring matter it contained having assumed a deeper shade: this is made probable as there is observed on the exterior of some ergots what appear to be the remains of the pericarp, which adheres in irregular little filmy pieces, and are occasionally seen external to the purple layer when sections are viewed under the microscope with strong powers and transmitted light, as in Tab. XXXIII. B. fig. 1. This happens when all the pericarp is not lifted up on the apex. Leveillé, however, and some others have not been able to discover any coat; for the former (*op. cit.* p. 573.) says, "On ne remarque pas de membrane à sa surface: les auteurs disent qu'il n'en existe pas, et en effet nous n'en avons jamais pu demontrer l'existence."

On applying very high magnifying powers to thin sections of the central part the structure is seen to be distinctly cellular, the cells however being very small, and in the rye about four times less than those of the healthy grain. Their arrangement is by no means regular, there being many variations in shape and size, as in Tab. XXXIII. B. fig. 1., which is a transverse slice, but in the longitudinal (fig. 2.) they have a greater tendency to be arranged in rows. Their contents likewise vary, some cells having one granule, apparently of an oily nature, which completely fills them, as in figs. 1. & 2.; others having two or three small ones, placed sometimes in the centre, as Phœbus observed; and others having granules which appear not oily, but very like the minute particles that are seen to be mingled with the fecula in the healthy grain.

The purple coat is not, as Phœbus figures it, composed of elongated cellular tissue, but of minute square cells, arranged in longitudinal rows between striæ or thicker places in the covering of the ergot, which may easily be mistaken for elongated cellular tissue, if a very high magnifying power be not used in the observation.

The terminal point or cap of the ergot, when examined microscopically, appears to be a heterogeneous mass of structure; being composed externally of the cerebriform coating of withered pericarp and of the sporidia, which cements together the various hairs that are found on the exterior of the grain, and which incloses likewise what is conceived to be the remains of the peri-

carp, which has been lifted up to this point by the seed in the interior putting on a state of development incompatible with the usual growth of that part. It has now become shrivelled from no longer containing the seed, and presents to the view a mass of broken-down porous tissue, so much so, that no regular structure can be made out of this as out of other parts of the diseased grain, though Leveillé mentions there are four or five parts radiating from the centre, but these appear nothing but those caused by its shriveling.

The proportion this appendage bears to the ergot is subject to much variation, as in the *Elymus* most frequently is found nothing beyond a tuft of hairs precisely such as exist on the healthy grain; but occasionally there is some remaining part of the pericarp, which is variable in size. In the rye the appendage is generally of about the same size, viz. one sixth or one eighth the length of the ergot, and appears to consist mostly of shriveled pericarp, on the apex of which is occasionally a sunken depression and a few rigid hairs surmounting it: when the pericarp is not lifted up by the seed within, the appendage is smaller, and occasionally some fragments of what appear pericarpial covering can be detected on various parts of the body of the ergot.

Thus it appears that this appendage is formed by the pericarp not growing so fast as the seed in its interior, thereby becoming torn asunder; still maintaining some adhesion, it becomes lifted up to the apex of the ergot by the great elongation of the seed, not always being central, often on one side, and its base strained over the apex of the ergotized grain, and not partaking of the nature of a fungus, as Leveillé imagined.

The number of ergots in any one spike of a grass is subject to much variation; in *Elymus sabulosus* there occur a great many, but in the smaller grasses only one or two, and in the rye the number seldom exceeds five or six. The appendage that each possesses in its perfect state is scarcely ever to be found existing on those specimens which are sold in the shops, being generally rubbed off in the collection of the specimens.

On pursuing the examination on the sporidia that exist on the exterior of the ergot, they were found to be of a lengthened oval figure, having their sides occasionally a little contracted about midway, of the forms represented at TAB. XXXIII. B. fig. 3.; there are, however, some variations in shape, some being nearly round, and others being longer than those in the above figures.

The size of the reproductive bodies is excessively minute, being not more on the average than the $\frac{1}{400}$th part of an inch long, and the $\frac{1}{6000}$th part of an inch in diameter; some few however being much smaller, and others larger than these dimensions.

Their number on one ergot, perhaps, is more astonishing than their minuteness; for by immersing in water a full-sized specimen from the *Elymus* when copiously covered, and making use of means for detaching them, a film was obtained which thickly covered more than a square inch of surface; consequently from a rough calculation there could not be many less than twenty millions of sporidia on this specimen, supposing the film was only one layer in thickness.

When these minute bodies are moistened with water and magnified about 500 to 600 times linear, their structure becomes just discernible, and there can be observed in their interior a rounded nucleus or granule, or sometimes two or three such, which are of a greenish colour*; very seldom it is that there are more than three; and occasionally sporidia will be found that do not contain any granules: all of which varieties are mentioned and accurately figured by Phœbus in his account of these bodies, and their dissimilarity as well as their containing small corpuscules caused him to doubt their being fungic sporidia.

The size of these granules was generally about one eighth or one tenth that of the body containing them, and may be calculated to be about $\frac{1}{4000}$th part of an inch in diameter.

Having kept some sporidia on a moistened glass, evident proofs were seen in a short time of incipient germination; and Philippar mentions, that when he moistened cloth and strewed sporidia upon it, they presented the appearance of having germinated: to examine this fact more perfectly, some of these bodies were placed on a slip of glass, moistened with distilled water, and covered with a thin plate of mica, and it was found immediately that a movement existed among them, such I considered as was discovered by Mr. Brown to exist amongst all fine particles, whether organic or inorganic, when placed so as to have free motion in water; the sporidia under observation never

* The green colour is owing to the minute body decomposing the light.

leaving the field of view, but possessing a tremulous movement, slowly approaching and retreating about their neighbours.

Having witnessed this for some time, and satisfied myself that the movements were such as are common to particles known as "active molecules," the object was set aside, covered with the piece of mica used in the previous observation, and placed under an inverted glass to prevent the evaporation of the water.

On examining it the next day, it was found that a few still retained similar movements to those witnessed the previous day, but the greater number presented appearances of commencing germination, in the various ways which here follow.

The most common method is that of the sporidia emitting a tube or tubes from some uncertain point or points (TAB. XXXIII. B. fig. 4.), but generally opposite the spot where a green granule is lodged in the interior. This tube increases to an uncertain length, and contains throughout its interior similar granules, arranged at short but generally equal distances between diaphragms, about as far from each other as they are in the interior of the sporidia; these tubes ultimately separate into fragments constituting as many fresh reproductive bodies.

In many other instances the sporidia, instead of producing a tube, give origin, opposite one of the granules, to a minute bud; this little point increases, becomes hollow, and ultimately separates from the parent as a perfect sporidium, frequently however before its separation showing an indication of producing a similar one from itself. (TAB. XXXIII. B. fig. 5.)

Another method of increase amongst these singular germs is that of the membrane composing the parietes of one of the sporidia breaking down, forming a flat patch, which keeps extending in all directions for a certain period, and developing upon itself granules, similar to those contained in the interior of the sporidia (fig. 6.).

The last and most remarkable manner of growth is that of the sporidia having a septum formed transversely across their interior, by a green granule extending itself laterally, and dividing them into two parts, each of which becomes again divided by a similar process; different states of which are represented in TAB. XXXIII. B. figg. 7, 8, & 9. By a repetition of this and other

methods there at last is formed a moniliform filament, which, though simple in its origin, ultimately becomes branched, the branchlets most commonly having a centrifugal development, radiating* from a central collection of cellules, and giving off innumerable joints, which become perfect sporidia (Tab. XXXIII. B. fig. 9. and 10.), which commence again the several methods of germination just detailed.

These granules appear important bodies, resembling probably the nature of the *nuclei*, which were first discovered by Mr. Brown in the cells of various organs, and since called *cytoblasts* by Schleiden in his description of ***Phytogenesis***; and these different methods of germination afford good illustrations of the manner of the formation of cellular tissue; and occasionally it happens that three of the methods, viz. pullulation, division, and the emission of tubes from the sporidia, may be detected in different parts of one little plant at the same time, as in Tab. XXXIII. B. fig. 9.

Whilst witnessing the daily increase and manner of development of this singular plant, an extreme number of green granules alone presented themselves, which had collected into one spot near the upper edge of the glass on which they were placed, and probably from being different in specific gravity from the water, had so collected by the glass having been kept in a position favourable for their so doing. These granules were about the $\frac{1}{4000}$th part of an inch in diameter, and possessed the movements of "active molecules," which was of greater range in proportion to their size than that observed in the sporidia before mentioned. On applying the highest magnifying powers it was found that these granules were similar to those in the interior of the sporidia, and sometimes were seen singly, at other times two united, and in a few cases three connected in a line, as at (Tab. XXXIII. B. fig. 11.). Being at a loss to conceive how these granules could escape from the body containing them,

* The radiating and moniliform character observed in this little plant, I consider is particularly owing to the manner in which it has been caused to grow; for being covered by a piece of mica, the sporidia or joints as they have formed have not been exposed to any cause likely to disturb the slender union they have with each other; and in this way they assume a condition which is unnatural, as on the ergot the articulations are scarcely ever found combined. I have noticed the same fact with *Torula cerevisiæ*, which has been made to grow without being disturbed, when a long string of sporidia could be seen, and with a slight agitation of the liquid not more than two or three could be afterwards found united.

some observations were made to discover the method, and it was found that very many sporidia did not emit tubes or germinate in any way, and evidently exhibited indications of the membrane which formed their parietes being injured and broken down, thereby allowing the granules to escape.

These atoms thus set at liberty, collected, as described, and could be seen singly, in pairs, or in threes; anxious to watch the changes these minute particles would undergo, they were daily examined for the space of seven or eight days, and it was observed that they ultimately appeared to become bodies like sporidia. During the first and second day no change was observed, but after this their margins could not be so well defined by the microscope, owing to a minute halo each presented: this I conceived originated from a glutinous exudation around the granule, which ultimately would harden into membrane and become the coat of the new sporidium: in this I was not mistaken, for after some days their size increased, and gradually appeared to approach the condition of other sporidia; those commencing with two granules had the appearance of two nuclei, those with three and one having their respective numbers also.

In this manner has been witnessed, by daily examinations, the growth of these sporidia, which, *being found on the ergot of every grass yet examined*, are without a doubt connected with the cause of its origin; the observations point out their various methods of germination, their advancement to maturity, and their ultimate production of the means of their increase; the little radiate plant seldom measuring more than $\frac{1}{200}$th or $\frac{1}{400}$th part of an inch in any direction.

From these observations the opportunity has occurred of confirming the fact, that this fungus is capable of existing when separated from the grain, not requiring that organ exclusively as its matrix, which fact was observed by Mr. Smith; the inference from which must be that the ergot can no longer be considered as a perfect fungus, but a diseased grain, as Leveillé described, though he somewhat erred in the nature of its production. The external appearances furnish the same proof, as at its apex can be seen the hairs that exist on the healthy grain, and occasionally also the remains of the styles; at its base is observed the pedicel, still supporting the two scales, consequently the intermediate portion is in the position of the body of the grain, and the

ergot that occupies this position ought to be certainly no other than the grain, which now differs from its healthy condition, from having in its early state supported a parasite which has communicated to it some disease, thereby perverting the normal state of its structure and development.

Notwithstanding the several parts of the grain are arranged as described, previous investigators, with the exception of Leveillé, have fallen into the error that the ergot was the fungus itself. Philippar appears to have viewed the matter in this light; still his expressions are somewhat vague respecting it, for (p. 122, *op. cit.*) it is stated, "Le grain ergoté, composé d'une substance fongique tassé et très étroitement serré, est le réceptacle des séminules, des globules ou bourgeons reproducteurs du champignon." In the same page the following expression is used: "le champignon"—"sortant de l'intérieur de la plante par le rachis ou l'axe des épillets du point réceptaculaire des organes sexuels." And lastly (p. 123), his opinion is given thus: "De tout ceci, je conclus que l'ergot est l'appareil reproducteur du champignon, qui termine ainsi sa végétation."

The reasons assigned by Philippar for considering it a fungus arise from its situation and from the microscopic examination of its structure, which he describes (p. 113) as beginning in the receptacle of the flower, and lifting up the sexual organs which become diseased but still remain on its apex. It is found, however, that where the paleæ are attached, and also the two scales, this part, which must be a receptacle also, is not diseased, as these organs remain undisturbed; consequently, it can only be the point where the grain and the receptacle unite that could give origin to any body taking the position occupied by the ergot. Yet from this point, which is firmly connected with the structure of the young grain, it is most singular that in every kind of grass yet found ergotized this supposed fungus should always burst through the tissue at that particular part, and at that particular time when the flower is about to expand. If it be a fungus, it ought also to burst forth as an ergot from the stem or some other place on the several grasses, besides growing between and parting asunder two organs, which were as firmly united to each other, in the young state, as the capsule of the poppy is to its flower-stalk; moreover, the ergot when matured, like the grain when ripe, slips out of the paleæ as a ripe filbert from its cupule, showing that it has no more organic

connexion, at this period, with the receptacle than the grain itself possesses.

Philippar's examination of the internal structure appears to have strengthened his view of its being a fungus; for he describes the body of the ergot to be composed internally of branched short fibres and globules of various sizes, round and oval, which he believes to be the means of its reproduction. My own observations on the internal structure differ somewhat from this, by proving that the fibres described are the boundaries of irregularly-sized cells, and not fibres at all; and the globules are not reproductive bodies, but for the most part those of a fatty oil and some other granular matters, which are contained in the interior of the cells, as seen in TAB. XXXIII. B. fig. 1., which is a transverse slice magnified six hundred times. In truth I have never seen sporidia in the interior of the ergot, if care be taken to exclude those on the exterior.

To witness these facts, take an ergot of rye, scrape away all its black coat, so as to remove all the sporidia which adhere to its surface; then make some very thin transverse slices, and let them be put on a slip of glass under the microscope; when water is added to them it speedily becomes turbid or milky, on account of the numerous particles that have escaped from the cells: these particles, however, are not *heavier* than the water, as the sporidia are, but are *lighter*, and collect on the surface, from whence they can be removed, like cream from the surface of milk. When magnified, they are found to be of very many sizes, some as large as the thousandth of an inch in diameter, and others so small as to be scarcely visible by the highest magnifying powers; when magnified about six hundred times their appearance very much resembles the globules seen in human milk. When the matter containing the fatty particles is heated, these minute globules liquefy, running together and forming either very large globules or numerous irregular masses, their primary form by this operation being completely disturbed, which would not have been the case had they been "séminules" or reproductive agents, as Philippar describes. To observe the structure of the cells, let some thin slices be made, and boil them in ether, which dissolves the fatty matter, and renders them transparent, so that the irregular cells can be readily examined, and by adding water afterwards to the ether a pellicle of fatty matter can be seen floating on the liquid.

Another argument against the ergot being a fungus is, that the reproductive particles are most numerous when it is young, and it continues its growth after their production has ceased, which is contrary to the usual law amongst that class of vegetable beings; for their efforts to live are only to develop the means of their propagation, commencing to decay the instant this act has been accomplished.

Besides these proofs, chemical analysis shows its dissimilarity in composition with *Fungi* generally, and even with the species of *Sclerotium* (a genus to which the Ergot was assigned by DeCandolle and Fée) on account of its containing very different constituents, the following being those given by Vauquelin in his analysis of the Ergot:—

Colouring matter: soluble in alcohol.

White oil: very abundant; sweet.

Violet matter: soluble in water.

Fixed phosphoric acid.

Azotized matter: very abundant, and alterable.

Free ammonia: at 100° Reaumur.

The fact of having caused the sporidia to grow unconnected with the ergot, and without assuming any form in the least degree analogous to it, is another, and the most substantial and convincing proof that the sporidia do not belong to that body, but are joints or portions of microscopic plants, which select the grains of many grasses as a suitable matrix for their development. There are other proofs of the separate existence of this microscopic plant; for it is not found exclusively on the body of the grain, but has been observed to flourish on other parts of the same grass, but occasioning in such situations no exuberant growth, for obvious reasons, because these parts have completed their development before the fungus makes its appearance; and their structure is not like that of the grain, which, at the period of attack, is exceedingly young, and, commencing to grow rapidly, is susceptible of impressions which can easily pervert its form and structure.

After numerous examinations respecting the nature of the Ergot of rye, and comparing the results with those obtained from other grasses* similarly af-

* The following are the grasses that have been examined when bearing ergots; most of the lower ones on the list were obtained in the neighbourhood of Greenwich:—

fected, it is conceived that the foregoing remarks have demonstrated that this body is produced by a particular species of fungus, which develops itself when it occupies the grain (whilst young), causing its remarkable alteration in form, colour, chemical composition and properties.

The manner in which this singular production probably originates (for at present much respecting this part remains uncertain) is, that the sporidia, or more likely the nuclei within them, are by some means introduced into the interior of the grass* and ultimately arrive at the grain, which they find the most suitable matrix for their development; or they may be brought into contact with the young grain from without, probably by the viscid fluid, but this is less likely to be the case, as the ergot can be detected before the paleæ have opened to admit the fluid.

When, however, they have been brought into contact with it, they lose no time in the work of reproduction, finding their way to the exterior, covering its body with multitudes of sporidia, and communicating disease to the healthy tissue, and thereby destroying so much of the coats as in the perfect grain constitutes the pericarpial covering.

Secale cereale.	Triticum repens.	Festuca pratensis.
Elymus sabulosus.	Dactylis glomerata.	Melica nutans.
Hordeum pratense.	Lolium perenne.	Alopecurus pratensis.
——— murinum.	Arundo phragmites.	

Phœbus gives a more extensive list than the above, amongst which he enumerates several kinds of *wheat*, *barley* and *oats* similarly diseased, together with some Cyperaceous plants.

* It is stated by Phœbus, and by Christison in his Treatise on Poisons, 2nd edit., that Wiggers had produced ergots by infecting the healthy grains previously with the sporidia. Leveillé also states (p. 570, *op. cit.*), "M. Simonnet s'en est assuré par une expérience très-simple, qui consiste à percer avec une épingle la partie inférieure de chaque fleur qui contient ce suc. Constamment cet observateur a vu l'ergot s'y développer." This last experiment is not of much value, for it generally happens that where the viscid juice exists there will be an ergot, whether a puncture has been made or not: the experiment ought to have been performed on those grains not moistened by any viscid juice.

Mr. Bauer (Penny Mag. 1833, p. 126 and 182,) has shown from interesting and delicate experiments, that the "smut-balls" on corn can be certainly produced by inoculating the seeds before sowing them with the sporules of the fungus producing such effects, viz. *Uredo fœtida* and *segetum*; and this excellent observer has proved that these bodies are carried into the interior by the sap after being absorbed by the roots, and it appears the most probable that the same takes place in the production of the Ergot.

Their presence* communicates disease most frequently to the entire grain; occasionally, however, only part of the albumen is attacked, and Tessier mentions this fact in these words: "C'est que la portion ergotée qui fait tantôt la moitié, le tiers ou le quart, est la plus voisine du support de l'épi et se trouve inserée dans la balle, occupant la place du germe au lieu que la portion semblable à du seigle est à découvert et la plus éloignée du support." These observations prove, from the position of the ergotized portion, that internal causes were more likely to effect such than external ones, and would countenance the opinion that the embryo was in such cases the part diseased; but these examples are so rare that that supposition cannot be maintained: on the other hand, it is to be remarked, that no trace of the embryo exists in the perfect ergot, and if it could have ever been impregnated, it must have been as speedily destroyed; and it is most likely that the grain is never impregnated, as the disease can be detected before the pollen is emitted; which fact coincides with Leveillé's observations, who says (p. 571.), "Souvent on rencontre les anthères collées à la surface; elles sont entières, lineaires, leurs loges *fermées* et remplies de pollen; circonstance, nous avons dit, qui avait été observée par Aymen et Beguillet, et qui prouve que le développement de la sphacélie précéde l'anthèse."

The diseased action thus engendered frequently destroys the vitality of the grain at the outset, so that it is unable to live under the effects produced by the fungus; specimens being sometimes found as if smothered by its rapid growth: when, however, the grain is not deprived of life, the diseased action vitiates all its constituents, and the perfect ergot soon takes the place of the healthy ovary, containing neither starch nor gluten, but an abundance of oily matter and other substances of a peculiar chemical nature.

From many experiments and examinations that have been made and repeated again and again, in order to obviate every source of error arising from

* I can see no objection to the supposition, entertained also by others, that there may be numerous kinds of parasitic plants whose germs arrive only at maturity in the interior of others, and which may be called *Entophytes*, which, like *Entozoa*, may have the power of selecting different organs as places of development, some choosing the stem and the leaves, and others the organs of reproduction. It is not to be conceived how so many fungi develop under, and then burst through the epidermis of many parts of plants, if this be not admitted.

the manner in which they have been conducted, it is considered the body known as an ergot may be defined to be *a substance composed of the diseased constituents of the grain occupying the position of the healthy ovary.*

Perhaps no vegetable substance has given rise to so many different opinions as to its cause as the Ergot. The earlier investigators supposed it to be owing to the puncture of an insect, and also to excessive moisture; some supposed it a habitation for living creatures; others followed, who considered it a fungus, which was called *Clavaria Clavus* by Münchausen, *Sclerotium Clavus* by DeCandolle, and lastly, *Spermoedia Clavus* by Fries, the same view being also entertained by Philippar. The "*Mémoire sur l'Ergot*" by Leveillé certainly approaches nearer the truth. He describes the Ergot as a grain diseased by a certain fungus, which he denominates *Sphacelia*, and assigns to it the characters given below*; still this intelligent observer is in error when he supposes that the appendage at the apex of the ergot is one of the conditions of the fungus, instead of being composed of the remains of the pericarp and hairs belonging to it, together occasionally with the remains of the styles; or, to use his own words, "Si ce champignon traverse les glumes sans éprouver d'accident on le voit a l'extrémité de l'ergot, ou il forme un tubercule jaune dont la consistance, le volume et la figure sont extrèmement variables."

Phœbus, the latest authority, considers the ergot to be the albumen altered "wir dürfen sie [Mutterkorn]" also "wohl für ein alienertes Eiweiss halten" (p. 104), and consequently to be a morbid grain of rye (p. 105), but denies that the "Blaschen" can be sporidia of a fungus, since they are of variable size and contain other smaller bodies.

From the foregoing observations it must be evident that the nature of an ergot is becoming better understood, from its origin being relieved of some of the obscurity that has hitherto enveloped it; therefore the former received opinions

* "Sphacelia. *Fungus parasiticus, mollis, viscosus* (forma indeterminata) *gyris exaratus, ex* 3 *vel* 4 *lobis apice connatis basi divisis et in axim confluentibus, constans. Sporulis globoso-ovatis nidulantibus.*"

"*Vere, in germinibus variarum graminearum, crescit, et præcipue secalis cerealis.*"

"Sphacelia *segetum* N. An eadem in omnibus gramineis?"

"Apicem germinis occupans, sphacelia fecundationi obstat, tamen ovarium crescit, sed gallarum more, et, pro forma elongata et curvata sub nomine *ergot* vel *clavi* designatur."

respecting it will now be untenable, and it will be requisite to correct also the botanical relations of this body, in order to assign to its assumed cause a position amongst the lowest of the divisions of *Fungi*.

On comparing the characters of the minute parasite of the ergot with those of British and foreign genera to which it is allied, it has been found so unlike any of them, as at present constituted, as to deserve being made a new genus, to which I have given the title of *Ergotœtia**; and after repeated examinations of the Rye and other grasses, I have not hitherto found any material difference in its organization or characters to warrant the making of those belonging to different grasses into different species; therefore I adopt the specific term *abortifaciens*† for the fungus found on the rye, and believe those on other ergotized grasses to be of the same species, when the ergots are of a similar character.

This minute plant, from its structure and habit, will be classed among the *Fungi*, and placed in the suborder *Coniomycetes* of Fries, and in the tribe *Mucedines*, or in Berkeley's arrangement of British *Fungi* in the tribe *Sporidesmiei*, which comprehends those genera which have their "*sporidia chained together into flocci at length free.*"

The British genera of this tribe are three,—*Aregma*, *Torula*, and *Spilocœa*; the first of which has sporidia opaque and pedunculated, whilst in the present plant they are transparent, and without peduncles; the second differs by having its sporidia filled with a grumous mass, whilst the plant under consideration has one, two, or three well-defined granules in their interior; and the last does not show the sporidia arranged in moniliform filaments.

The characters by which the plant may be recognised are the following:—

Ergotœtia. Sporidia elliptical, moniliform, finally separating, transparent, and containing seldom more than one, two, or three well-defined (greenish) granules.

E. abortifaciens. (Characters as above.) Vide Tab. XXXIII. B. fig. 3—11.

* Derivation from *Ergot*, Fr. (Ergota *Pharm. Lond.* 1836), and αἰτία, *origo*.

† When this paper was read before the Society, the specific name used was *abortans*, which was intended to apply directly to the fungus destroying the germinating power of the grain, and indirectly to the more remarkable properties of the ergot. This term, however, is not grammatical, and by the suggestion of J. Pereira, Esq., the present one has been substituted.

There is a point which, as regards the medicinal properties of the ergot of rye, is deserving of being mentioned in this place, from having found in numerous instances that the specimens obtained from various grasses have frequently been not much more than hollow cases, instead of being solid. On looking for the cause, it was found that this excavation had been effected by numbers of a small species of *Acarus* (Tab. XXXIII. B. fig. 12.), which had devoured the interior; consequently, if the medicinal virtues reside in that part, which however is disputed, the specimens must become inert. The destruction that these tiny creatures make will become apparent by the following statement obtained from a friend, viz.: that from six pounds of ergot of rye, kept six months in the same paper, six ounces of powdery excrementitious matter was obtained; therefore the practice of keeping camphor with the ergot is likely to prevent the attacks of these minute depredators.

EXPLANATION OF TAB. XXXIII. B.

Fig. 1. Represents a transverse section (*extremely thin*) of the body of the ergot, magnified seven hundred times, exhibiting irregular-shaped cells, containing granules of various sizes, and the purple envelope, with some membranous portion adhering, probably remains of pericarp.

2. A longitudinal section of the same, showing also the granules contained in the cells, the latter appearing to be disposed in somewhat regular rows.

3. Shows different kinds of sporidia, which contain granules of various numbers, the first having none.

4. Represents their germination by emitting tubes which contain granules similar to those in the interior of the sporidium, from which they arise.

5. Is the manner of germination, by giving off minute buds, which ultimately become sporidia, four, five, or more, adhering occasionally together, and finally separating.

Fig. 6. Shows the membrane of one of the sporidia, laid open, increased in size, and developing granules on various points of its surface.

7. Shows the manner in which the sporidia become divided by a septum or septa, by the granules extending themselves transversely; different stages being observed in the first and succeeding ones.

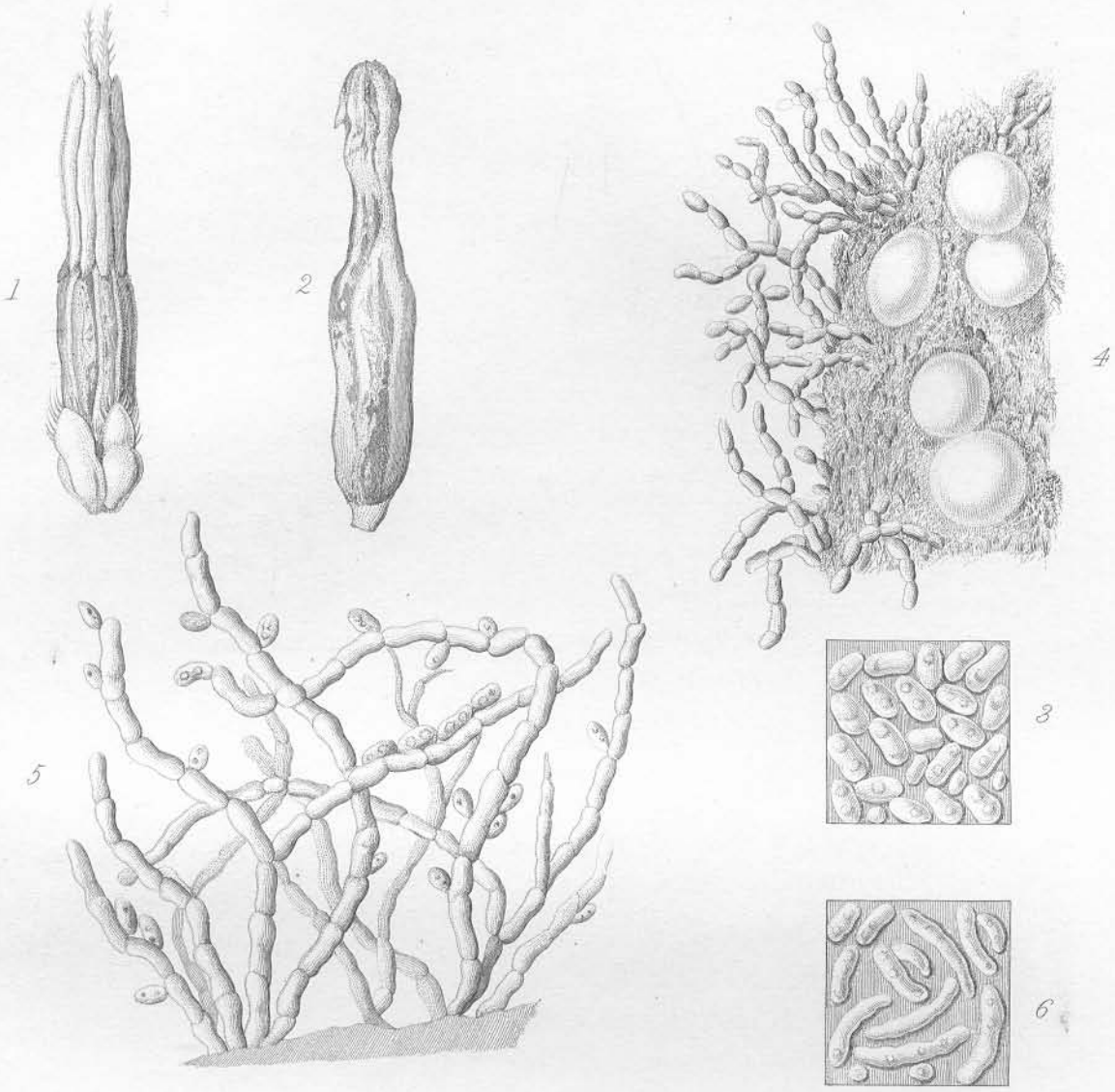
8 & 9. More advanced states of growth.

10. The fungus, assuming a radiating form, and developing sporidia upon its branches.

11. Granules from the interior of the sporidia, arranged singly, or in twos or threes. All the preceding figures magnified seven hundred times.

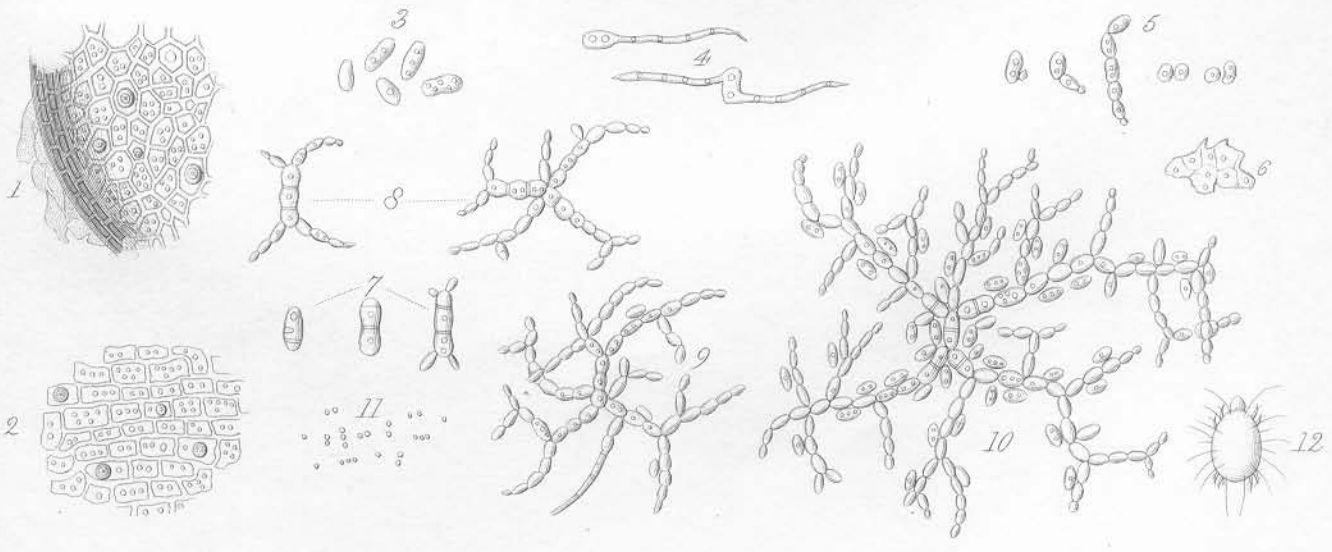
12. The Acarus, which lives on the interior of the ergot, magnified fifty times.

A



Franz. Bauer. 1839.

B



E. J. Quekett del.

G. Jarman Sc.